4. Ecological characteristics of recorded species

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Table 1.

Summary of the biological characteristics of each species. SC, species code (see List of recorded species, Section 2); HT, height; WF, water flow; PL; pool. AG algae. Significance of correlation (semi-partial correlation; Cohen et al. 2003) between the frequency of occurrence of each species (Fig. 3) and environmental variables (HT, Table 4; WF, Table 5; PL, Table 6; AG, Table 7) are shown (+ +, strong positive correlation, $P < 0.01$; +, positive correlation, $P < 0.05$; – –, strong negative correlation, $P < 0.01$; –, negative correlation, $P < 0.05$). GR, geographic range of species. Each species was assigned to one of the four categories, i.e., N (northern species), S (southern species), E (extended-range species), and L (limited-range species). The ranges of these groups along the Pacific coast of Japan are: N, >35 °N; S, <35 °N; E, from <30 °N to >35 °N; L, 30–35 °N (Higo et al. 1999, Okutani 2000). MG, morphologic groups including three categories, i.e., Lp (limpet-form species), Sn (snail-form species), and Se (sedentary species). FH is feeding habit, which is shown as H (herbivore), P (predator or parasite), D (detritivore), S (scavenger), or F (filter feeder). An asterisk indicates that the reference information (Ref) belongs to a different species that is in the same genus as the species concerned. DV, pattern of development exhibited as Tp (totally planktonic development, i.e., larvae experience planktonic life after external fertilization), Pp (partially planktonic development, i.e., veliger larvae hatch from a mass of laid eggs), Dd (direct development, i.e., juveniles crawl out from adult females or laid eggs), or Pl (planktonic development, i.e., either Tp or Pp but exact information is unknown). References for development are shown as numerals in the right-hand column (Ref). The intensity of harvesting by local people (HV) is shown with a qualitative evaluation of + + (heavy) or + (light), based on the observations of the authors in the study area from 1985 to 2010. References for the feeding habit and development of each species are as follows (for details, see References in Section 9).

1) Abe (1980a), 2) Abe (1980b), 3) Amemiya (1928), 4) Amio (1963), 5) Braley (1982), 6) Bullock & Harper (1994), 7) Fretter & Graham (1994), 8) Habe (1943), 9) Habe (1956), 10) Hadfield et al. (1972), 11) Hawkins et al. (1998), 12) Hayes (1983), 13) Hirano (1981), 14) Hirano (2000), 15) Houbrick (1985), 16) Houbrick (1992), 17) Houbrick (1993), 18) Hughes (1974), 19) Ishida (2001), 20) Ishida (2003), 21) Iwasaki (1993), 22) Iwasaki (1996), 23) Iwasaki (2005), 24) Iwata (1952), 25) Iwata (1999), 26) Katagiri & Katagiri (2007), 27) Kato T personal communication, 28) Kizaki (1987), 29) Kohn (1970), 30) Kohn & Nybakken (1975), 31) Koike K personal communication, 32) Kojima (1957), 33) Kubota (2006), 34) Kuroda et al. (1957), 35) Kuwamura et al. (1983), 36) Maeda (1986), 37) Masuda (2007), 38) Matsunaga (1964), 39) McLean (1962), 40) Miyazaki (1935), 41) Miyazaki (1938), 42) Morton (1956), 43) Niina & Kubota (2009), 44) Nishihama et al. (1986), 45) Ohgaki (1997), 46) Ohgaki (2005), 47) Ohgaki personal observation, 48) Omi & Kuramochi (2001), 49) Ostergaard (1950), 50) Ota & Tokeshi (2000), 51) Pastoureaud et al. (1996), 52) Robertson (1970), 53) Rosewater (1970), 54) Satomori (1982), 55) Senawong (1971), 56) Steneck & Watling (1982), 57) Sumikawa (1963), 58) Switzer-Dunlap (1978), 59) Takada (1996), 60) Takada (2001), 61) Takada (2003), 62) Taki & Saito (1999), 63) Tanaka (1957), 64) Tanaka (1960), 65) Tanaka (1970), 66) Taylor (1976), 67) Usuki (1970), 68) Usuki H personal communication, 69) Wada (1986), 70) Webber (1977), 71) Yamaguchi (1992), 72) Yamamoto (1997), 73) Yonge & Thompson (1976), 74) Yoshida (1953), 75) Yoshida (1960), 76) Yoshioka (1988), 77) Yukihira et al. (1995), 78) Yusa Y. personal communication

Table 1–1											
SC	HT	WF	PL	AG	GR	MG	FH	Ref	DV	Ref	HV
1					E	Lp	H	6			
2	−−	−			E	Lp	H	6			
3					N	Lp	H, P*	39			
4	−				E	Lp	H, P	44	Tp	76	+
5					S	Lp	H*	56			
6		+ +			L	Lp					
7	−				E	Lp	H*	56			
8		+ +			L	Lp	H*	56			
9					E	Lp	H	62			
10		+ +			S	Lp	H	21			
11					E	Lp	H*	21, 56	Tp	4	
12					L	Lp	H	13			+
13	−				E	Lp	H	13, 21	Tp	4	
14		−	+		E	Lp	H	13, 60	Tp	4	
15		−−			S	Lp	H	13	Tp	4	
16		+ +			L	Lp	H*	56			
17					E	Lp	H*	56	Tp	4	
18		+ +			E	Lp	H*	56			
19					N	Lp	H*	56			
20		−		+	E	Lp	H*	60	Tp	4	
21	−−	−−			L	Lp	H*	60			
22			+ +		N	Lp	H	60			
23	−−	−−	+ +		N	Lp	H	60	Tp	4	
24					N	Lp	H	34	Tp	4	+
25	−				E	Lp	H	23	Tp	4	+ +
26		+ +			Sk	Lp	H*	23, 56			+ +
27		+ +			E	Lp					
28	−				L	Lp					
29	−−				N	Lp					
30					N	Lp					
31					N	Sn	H	23			+
32					N	Sn	H	23			+
33					E	Sn	H*	23			+
34				+	S	Sn					+
35					N	Sn					+
36			+		N	Sn	H	23			+
37					Sk	Sn					+
38		+ +		+ +	Sk	Sn					+
39		+			S	Sn					+
40					Sk	Sn					+
41	−−				S	Sn					+ +
42					S	Sn					
43			−		N	Sn					
44	+ +				N	Sn	H	23, 60	Tp	57, 59	
45					N	Sn	H*	23, 56			
46					N	Sn					
47					N	Sn					
48		+			S	Sn					
49		+ +		+	Sk	Sn					
50					S	Sn					

Table 1–2											
SC	HT	WF	PL	AG	GR	MG	FH	Ref	DV	Ref	HV
51					Sk	Sn					
52		+ +			N	Sn	P	23, 27			
53					N	Sn					
54	− −	− −			S	Sn					
55					L	Sn					
56					L	Sn					
57	− −	− −			S	Sn					
58	− −	− −			L	Sn					
59					S	Sn					
60		− −	+		N	Sn	H	23, 77	Tp	4	+
61	− −				S	Sn	H*	23, 56			
62	−				S	Sn					
63		−			S	Sn	H	23	Tp	23, 31	
64	+ +				L	Sn	H	60	Dd	2	
65					Sk	Sn	H*	23, 56	Tp	31	
66					L	Sn					
67					Sk	Sn	H, D*	16			
68					Sk	Sn					
69					L	Sn					
70			+ +		S	Sn	H, D	15, 36	Pp	15	
71			+ +		E	Sn			Dd	17	
72			+ +		S	Sn					
73	+				S	Sn			Pp	45	
74					S	Sn					
75					Sk	Sn			Tp	4, 49	
76					S	Sn			Tp	53	
77	+ +				E	Sn			Tp	4, 9	
78	+ +				N	Sn	H	46	Tp	4, 9	
79	+ +				S	Sn	H*	46	Tp	4, 9	
80	+ +				S	Sn	H*	46	Tp	4, 9	
81	+ +				E	Sn	H	28, 61	Tp	4, 32	
82			+ +		N	Sn	H, D*	7, 56			
83					L	Sn					
84					S	Sn	H, D	69	Pp	35	+ +
85					S	Sn	H	36			
86	− −				E	Se	H,P,D	23, 38	Dd	4	
87	− −				S	Se					
88	− −	− −			S	Se					
89				+	S	Se	F*	7, 73	Dd	4	
90					N	Se	F	73	Pl	73	
91		+ +			L	Se	F*	10, 18			
92					Sk	Se	F*	10, 18			
93					L	Se	F*	20, 36			
94	−				N	Se	F	20, 36	Pp	4	
95					S	Sn	H	36, 71			
96					S	Sn					
97					S	Sn					
98					S	Sn					
99		+			S	Sn	H>P	48, 71	Pp	49	
100					S	Sn					

Table 1–3											
SC	HT	WF	PL	AG	GR	MG	FH	Ref	DV	Ref	HV
101					S	Sn					
102					S	Sn					
103					E	Sn	P>DH	23			
104					S	Sn	P>H	12	Pp	49	
105					S	Sn					
106					S	Sn					
107		+ +			S	Sn					
108					S	Sn	H	71			
109					S	Sn			Pp	49	
110					S	Sn					
111					S	Sn	P*	7			
112					L	Sn	P*	7			
113					S	Sn	P*	73			
114					S	Sn	P	36			
115	− −	−			S	Sn					
116	− −	−			L	Sn	P*	7, 52			
117					N	Sn	P*	7, 52			
118					L	Sn	P	8			
119	− −				N	Sn	P*	7			
120					L	Sn	P*	7			
121					S	Sn					
122	− −	− −			S	Sn	P>S	1, 19			
123	− −	− −			E	Sn	P, S	1, 19			
124		−			Sk	Sn	P	1	Dd	72	
125	−	−			S	Sn	P*	1			
126					Sk	Sn					
127					Sk	Sn	P*	52, 66			
128					Sk	Sn	P	66			
129	− −				S	Sn	P*	1, 66			
130	−				S	Sn	P	1			
131	− −	− −			Sk	Sn	P*	1, 66			
132	− −	−			S	Sn	P	1, 19			
133					Sk	Sn	P*	1, 66			
134					S	Sn					
135					S	Sn	P	66			
136					Sk	Sn	P*	66			+
137					S	Sn	P*	66			
138		+ +		−	Sk	Sn	P*	66			+
139					Sk	Sn	P	66			+
140					Sk	Sn	P	66			
141	− −				N	Sn	P	1, 23	Pp	4	+
142	− −				N	Sn	P	1, 23	Pp	4	+
143	− −				E	Sn	P	1			+
144					S	Sn	P*	52, 66			
145	− −				S	Sn	H	68	Dd	4	
146	−				L	Sn	H>S,D	23	Dd	4	
147					S	Sn					
148					L	Sn					
149					E	Sn			Pp	4	
150					N	Sn					

Table 1–4											
SC	HT	WF	PL	AG	GR	MG	FH	Ref	DV	Ref	HV
151					S	Sn					
152					E	Sn			Pp	4	
153					Sk	Sn					
154					E	Sn					
155			+ +		S	Sn					
156			+ +		N	Sn					
157					L	Sn					
158					S	Sn	P, S	23, 50			
159					S	Sn	P	29			
160					Sk	Sn	P*	29			
161	− −	− −			S	Sn	P*	29			
162				+	Sk	Sn	P	30			
163					E	Sn	P	30			
164					Sk	Sn	P	30	Pp	70	
165					S	Sn	P	30			
166					Sk	Sn	P	30			
167					Sk	Sn	P	30			
168					L	Sn					
169					Sk	Sn					
170					L	Sn	P	25			
171					N	Sn	P	25			
172					S	Sn					
173	− −	− −			E	Sn	P	33	Pp	49	
174					S	Sn					
175					N	Sn	H	14	Pp	4	
176					S	Sn					
177					S	Sn					
178					N	Sn			Pp	4	
179					S	Sn	H*	14	Pp	58	
180	− −	−			E	Sn	H	14, 67	Pp	58, 78	
181	− −	− −			E	Sn	H	14, 68	Pp	4, 78	
182	− −	− −			S	Sn	H, S	23	Pp	78	
183					E	Sn	H	14, 23	Pp	4, 58	
184					S	Sn			Pp	4, 58	
185					L	Sn	P	14			
186					S	Sn					
187					L	Sn	P>H,D	14, 23	Pp	43	
188					S	Sn	P	14			
189					S	Sn	P	14			
190					S	Sn	P	14			
191					S	Sn					
192					E	Sn	P>D	14, 23			
193					S	Sn	P	37	Dd	43	
194					S	Sn	P	14	Pp	49	
195					?	Sn					
196					L	Sn					
197					L	Sn			Dd	26	
198	+ +				L	Sn	H*	21			
199			−		N	Sn	H	13	Pp	4	
200	−				N	Sn	H	21	Pp	4	

Table 1–5											
SC	HT	WF	PL	AG	GR	MG	FH	Ref	DV	Ref	HV
201					L		F*	73			
202					E	Se					
203					E	Se					
204					Sk	Se					
205					E	Se					
206					S	Se					
207	−−				E	Se					++
208					S	Se					
209		++			N	Se			Tp	40, 74	
210		++			N	Se			Tp	24, 57	
211	++				L	Se					
212	−−				S	Se	F	55	Tp	47	
213	−				S	Se					
214		++			N	Se			Tp	47	
215					Sk	Se					
216		+			N	Se	F	55			
217					L	Se					
218		+			Sk	Se					
219					Sk	Se			Pl	65	
220	−−		+		S	Se			Pl	34, 63	
221	+				Sk	Se					
222		++			S	Se					
223					S	Se					
224					S	Se			Tp	54	
225					S	Se					
226		++		+	S	Se					
227					E	Se	F	51	Tp	3	
228					N	Se			Tp	3	+
229		−−			E	Se			Tp	3, 64	
230			−−		Sk	Se	F	11	Pl	5	
231					S	Se					
232			−		E		F*	42	Dd	22	
233	−−				E	Se					
234					E	Se					
235					S	Se					
236					S						
237					Sk						
238					N						
239					S				Pl	75	
240					E						
241					Sk						
242		++			S	Se			Pl	41	